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PHYSICAL FACTORS
IN READING

SELECTED GRADUATE
STUDENT PAPERS

Edited by
THOMAS E. CULLITON

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Physical Factors in Reading

EDITED BY THOMAS E. CULLITON
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Selected Graduate Student Papers from the Course Physical Factors in Reading

Edited by THOMAS E. CULLITON

Introduction

Since the 1966-1967 academic year, the course Physical Factors in Reading has been offered at Boston University by having medical specialists lecture to the students in their specialties. The lecturers have been specialists in obstetrics, neurology, pediatrics, psychiatry, ophthalmology, internal medicine and dermatology. In addition educators, Boston University Staff members, with specialties in related fields lecture to the students in their respective fields.

The three articles to follow represent topics which reflect the interests of three groups of students from this class.

The editing of the manuscripts has been done because of space limitations in final publication.

Several papers could have been included in this Journal, however due to the salience of the subject matter these three papers were selected.

The first paper Visual Fatigue and Reading has been written by Lorraine A. DeMilia, a doctoral candidate in the Division of Curriculum and Instruction. Miss DeMilia is a teaching fellow at Boston University and is working in elementary reading.

The second paper Educational Implications of Glandular Malfunctioning has been written by Winona Chang, Tina Federico and Elaine Fitzpatrick, all doctoral candidates in the Division of Curriculum and Instruction. Mrs. Chang is working toward her doctorate in elementary language arts. Miss Federico is a reading specialist in the Waltham Public Schools, in Waltham, Massachusetts, and is working in secondary reading. Mrs. Fitzpatrick is on the faculty at Boston State College and is working in secondary reading.

The third paper has been included for its concern with Chemotherapy and the Hyperkinetic Child. The authors of this paper are: Estelle P. Epstein of the Horace Mann Laboratory School, Salem, Massachusetts; Nancy D. Harrington, Salem State College; Dr. Judith A. Meagher, University of New Hampshire; Elisabeth L. Rowlands, Rhode Island College; Ruth K. Simons, Salem State College.

Visual Fatigue and Reading

LORRAINE A. DEMILIA

Introduction

The purpose of this paper is to summarize and discuss some of the relevant scientific literature on visual fatigue, with special emphasis on the following:

1. the psychology of word perception
2. the determinants of legibility
3. the role of various typographical factors

Visual fatigue is a subject of increasingly important concern, since the current demands made upon our eyes by required reading material is unparalleled in human history. Consider the number of books published each year and the quantities in which they are being sold and read. Look at a newspaper stand any morning, or at a subway in which people on their way to work bury themselves in a sea of papers. Those not reading the news are probably reading the advertisements printed on the subway cards. Students are far from the only people required to read during the day, week after week and year after year. Most working people are taxed with a great deal of technical material to read and statistics to follow. People on the highways are assaulted with billboards and a complex arrangement of directional signs. For relaxation, hundreds of magazines and periodicals are being sold on the market. Filmgoers are more likely to be confronted with subtitled foreign films now than they were ten or twenty years ago. Television programs broadcast printed commercials every fifteen minutes or so.

The woman in the supermarket is surrounded by thousands of food labels and sale announcements to be read; the child playing manufactured games is faced with rules and directions; the family in the restaurant must read through menus before they may eat. Never before has there been so much emphasis on the printed word as essential to the functions of everyday living.

Visual fatigue, as we will see, does not result primarily from prolonged exposure to printed matter or extensive involvement in reading. The main causes involve the legibility of written materials. In this paper we are concerned with the basic problems of legibility and how

they affect visual fatigue. It is not likely that the amount of printed material in our environment will be reduced during the coming years; we, therefore, must examine the ways of improving the quality of legibility of the materials we will have to read. This more than anything else may contribute toward saving eye-sight.

Serious research in oculomotor behavior and the effects of typographical factors was conducted at the end of the nineteenth century and the beginning of the twentieth, yielding results which provided bases for more modern research. Unfortunately, some of the most exhaustive research was conducted during the earlier part of this century. This is unfortunate in two respects: the techniques employed did not always have the advantage of modern scientific apparatus, and the design of recent printed material has changed in some instances. But while this early testing suffers from these two drawbacks, the results produced are not obsolete. In fact, many modern studies in the same areas as these earlier studies confirm the validity of that research.

This is quite fortunate, because there has been less exhaustive testing in recent years than one would expect. Miles Tinker (University of Minnesota), among other investigators in the field, has continued to publish new books on this subject; but for the most part we are obliged to rely on early studies.

In this paper the nature of visual fatigue; oculomotor patterns; and the effects of typography, paper, color and illumination on reading are discussed. The most significant studies in these fields are referred to whenever possible. Where early data have been refuted and no recent studies have been conclusive, only general conclusions will be drawn. While certain specifics have not received universal acceptance, such as the relative importance of individual letters in legibility or the relative legibility of all typefaces, enough is known in all the major areas to make an intelligent presentation of this field.

Fatigue

When we speak of visual fatigue, we are dealing with a term which we cannot use glibly. The word "fatigue" is so much a part of our everyday conversation that we must arrive at a specific definition here in order to know what it means in the precise context of this paper. The general definition of "tiredness" is too vague to be of real use and too imprecise to be the subject of scientific inquiry.

R. A. Spaeth (1919-20) defines fatigue as:

the decreased capacity for doing work as a direct result of having worked; the amount of decrement varies with the duration, rate, and intensity of the work, and with the initial strength or capacity of the organic mechanism involved. (31)

This definition serves as a good point of departure. Spaeth wrote the above in an article in the JOURNAL OF INDUSTRIAL HYGIENE; he focused, therefore, on the relationship of fatigue to work, defining fatigue in terms of its cause (i. e., resulting from having worked), and emphasizing its effect on productive output. This is only one way of defining fatigue.

A psychologist might be primarily concerned with the psycho-emotional aspects of fatigue. That is, he might define fatigue as the state in which the motivation to continue work is diminished due to prolonged participation in some activity. This is, in the psychological aspect, accurate. Experiments, however, have shown that even when the motivation to continue work is weak as a result of prolonged work, the output of the ensuing period of work is not necessarily diminished in quantity nor is it invariably characterized by poor performance. In this respect, the psychological definition conflicts with Spaeth's industrial-oriented definition.

Other definitions would probably be variations on the idea of work decrement resulting from prolonged activity, each offering certain modifications determined by context.

Basically there are two approaches to understanding the nature of fatigue. The subjective approach, which embodies weariness and motivational lag, is based on the subject's feelings of fatigue. Motivational lag can be tested, but it is difficult to test generalized feelings of weariness without going into neurological patterns or body chemistry. At that point one enters the realm of the second, or objective, approach. The objective approach determines the fatigue state from physiological factors. It involves the biochemical decomposition of those substances which are necessary for activity (work), resulting in the loss of energy for the individual. Extensions of this view deal with the role of toxins in the blood stream which are metabolically produced. But it would be an unnecessary digression to thoroughly examine histological and neurological processes underlying fatigue in general. Let us simply draw the distinction between subjective and objective views at this point.

The factor of work decrement, which we may consider at least a corollary to any definition of fatigue if not an intrinsic part, can be measured in two ways. One measure is the amount of output effected by a fatigue state; the other is the quality of output. For example, a fatigued worker may either work at a slower rate, or he may sustain his normal work rate with less accuracy. As has been pointed out, these are not the only alternatives since efficiency may be maintained even when the desire to work is decreased. We are not concerned here with the question of whether efficiency necessarily decreases with the onset of fatigue. We are, however, interested in the factors which come into

play during an examination of the nature of fatigue. Generally, then, these factors are the effect of prolonged activity on the organism, motivational lag, decrease in the quantity of output, and failure to sustain peak quality in work. The basic problem with which we are concerned is how these factors apply to visual fatigue and, more important, what produces this state.

First, it is necessary to survey the components of the visual mechanism. This means not only how we see, but what we see as well.

Sense receptors are stimulated by only a fraction of the total known energy spectrum; only a narrow band of the wave lengths of radiant energy affect the organism. In the eye, radiant oscillations having wave lengths between 350 and 750 millimicra (one millimicron is one millionth of a millimeter) activate the visual mechanism. After direct or reflected radiation reaches the front surface of the eye, it is brought to sharp focus on the retina and an image is formed. (We are probably familiar enough with the photographic plate analogy that we need not repeat it here).

The differentiated reflection and absorption of radiant energy and its stimulating effect are basic to our perceptions of brightness, color, pattern, visual acuity, and tridimensional vision. Color is perceived in the cones of the visual mechanism, which are light-oriented; the rods are darkness-oriented for vision in conditions of poor illumination, and they do not perceive color. Altogether there are some 137 million rods and cones in the eye.

There are some other fundamental considerations in the working of the eye which should be mentioned here. Six external muscles provide the rotation of the eyeball, which is one of the most significant elements in the reading process. Another consideration of possible importance is the complex function of both eyes acting in relative synchronization. It has been suggested that some visual fatigue may result from the failure of both eyeballs to perform similar rotations simultaneously. (19) Our concern will not be with the role of eye disorders in visual fatigue; what we wish to determine are the external factors.

It has been found that during long periods of continuous visual work (such as prolonged reading) the total activity of the receptor-neuromotor mechanism of the eye establishes a "steady state." That is, the eye achieves and maintains a regular pattern of work, just as the heart does. Similarly, as the heart does not show fatigue from prolonged normal functioning, the eye does not undergo fatigue from simple prolonged exposure to work under normal conditions.

It is, then, in the absence of optimal conditions that fatigue results. In 1939 M. Luckiesh and F. K. Moss proposed that the visual mechanism temporarily compensated for poor conditions of seeing by an increased expenditure of energy. (23) That is, the eye maintained nor-

mal efficiency at a cost to the organism. As this energy was depleted, visual fatigue set in. This not only corroborates the biochemical view, but it explains how efficiency can be maintained after motivational lag occurs.

Visual fatigue, we may assume, is not so much a function of prolonged activity, such as reading, as it is a function of eye strain. The causes of eye strain are, therefore, the concerns of this paper. In our examination of reading and visual fatigue, we will try to determine what constitutes poor conditions for reading and what constitutes optimal conditions. This will involve us in the problem of illumination, the effects of color contrast, and most intensively the role of typographical factors in creating reading conditions.

We have taken a brief look at how the visual organism perceives. The next subject of investigation is how the eye functions in reading. This will lead us to understand word perception, since we will then be able to measure whether or not the eye is functioning normally in different reading situations. Eye movements are as important a factor in objectively determining the quality of reading as rate of speed and accuracy.

Eye Movements

In reading a line of print, the eye does not sweep fluidly but makes several stops. These stops are called fixation phases. During each fixation pause, a group of words are perceived. Normally, 93-95% of reading time is spent in fixation pauses.

The movement of the eye from one fixation pause to another occurs as a quick jerk, called a saccade. Saccadic movement is so rapid that we are not aware of it as we are reading. Eye movements in reading are, in one respect, analogous to the movements of a typewriter carriage when a fast typist is working: the carriage appears to move smoothly and fluidly, but it is actually only a series of quick stops.

There are two other significant eye movements in reading. One is the regression. This occurs when the eye moves backward to reread a word or group of words in order to attain clearer comprehension. Poor reading is highly characterized by excessive regressions.

The other movement is the eye movement from the end of one line to the beginning of the next; this is called the return sweep. These four movements (fixation pause, saccade, regression, and return sweep) constitute the visual process of reading. Experiments have attempted to determine the number of fixation pauses per line of print in different situations, such as using different typographical factors, material of different complexity, and readers of different levels of efficiency; the proportion of fixation pauses to regressions in these various situations; the proportionate amounts of time spent in fixation pauses, regressions, sac-

cares, and return sweeps; and the eye-voice spans during fixation pauses (these include the number of words perceived in each fixation during silent reading as well as reading aloud).

Attempts to measure these factors began at least as far back as the beginning of this century. In France in 1906, L. E. Javal tried to count the number of fixations per line by attaching a tiny microphone to the upper eyelid. (34) He had little success with this technique.

Fairly successful results were obtained in 1898 by B. Erdmann and R. Dodge in Germany (13) and in 1916 F. N. Freeman in the United States (14) by placing mirrors in front and slightly to the right of the reader in order to allow the experimenter to watch his eye movements from behind. In 1929, Miles and Segal also used this method. (34) But in 1928 Miles also introduced a new technique: he observed the reader through a peep-hole in the reading matter, counted the number of eye movements per copy, and divided this number by the number of lines in the matter read.

Another technique involving an apparatus attached to the eye (in the line of Javal's microphone) was first used by A. Ahrens in Germany in 1891 (1) and in 1898 E. G. Delabarre in this country (11). A tiny lever was attached to the cup of eye, which activated an aluminum marker; the marker was suspended over a smoked drum so that all horizontal eye movements were recorded. To record the reading time, the marker was in circuit with an electric current interrupted regularly by a tuning fork: a spark would jump from the end of the marker to the metal drum, it punctured the paper and displaced a spot of soot. Although this technique was extremely complex (without really enjoying the advantage of sophistication), in 1900 E. B. Huey found it quite fruitful. (17)

The next development in testing techniques involved photographic methods. The variations and refinements of this approach were numerous. Attempts will not be made to go into each of the photographic experiments. Our concern here is to survey the methodology of testing eye movements in reading during the growth of the century, with the emphasis on the final criteria established for such testing; we will summarize the results later, since different conclusions were reached by too many experimenters, the validity and accuracy of whose techniques may be questioned.

Photographic methods began to yield the best results, with motion picture techniques found to be superior to the photographic plate. (18) Dodge and Cline considered the various techniques which had been employed in the testing of eye-movements and established the following criteria for future testing: (12)

1. Eyes must be able to operate under the normal conditions of binocular vision.

2. The apparatus must be capable of registering the movements of eyes simultaneously.
3. The unit of time measurement must be one millisecond or less. Photographic methods were only capable of measuring in hundredths of seconds; they were employed, however, with the results being converted to milliseconds.
4. The registering medium must have no motion or inertia.
5. The apparatus should be flexible enough to use on a large number of subjects without serious inconvenience.

The technique they devised adhering to these criteria was the best method to date; and, with refinements and modifications from time to time, it set the pace for further research. Dodge and Cline suggested directing a beam of light into the reader's eye; on striking the eye, the light is reflected from the surface of the cornea into a camera where a falling photographic plate (and later, motion picture film) records changes in the direction of the beam occurring with each movement of the eye. This, of course, was employed with beams directed into both eyes simultaneously.

The basic advantages of this technique were the elimination of an apparatus attached to the eye which could be either harmful or unnatural in the reading situation, the elimination of the dependence on the observer's accuracy in counting movements, and the elimination of the similar dependence on the observer's memory span. Timing data in Dodge and Cline's technique were obtained by interrupting the beam of light every hundredth or fiftieth of a second, which automatically registered on the film.

Let us leave the history of testing methods and turn to some results. Many tests reveal that good readers make few regressions and poor readers make many. The number of regressions, it has been determined, increases with the complexity of the ideas in the text. A further conclusion drawn is that the complexity of eye movements, indicated by the number of regressions, is directly correlated with mental processes.

The minimum pause duration, further tests have revealed, is greater than 100 milliseconds per fixation; regressions averaged 170 milliseconds. The normal proportion of time taken by eye movements (saccades) is 6.4% of the total reading time. It has been found that the college students reading prose of fourth grade difficulty (silently) in one group of experiments exhibited a high proportion of time taken by saccadic movements (9.6%), whereas the lowest proportion of time taken (5.3%) occurred when college students read algebra problems which included equations. These results suggested that ideas expressed directly in clear symbols improved the rate of reading over ideas of less complexity which demanded greater mental work in recognizing

the ideas. It must be remembered that these experiments were testing only the rate of reading, rather than the accuracy of comprehension. Even though the factor of comprehension was not considered here, the ability to perceive an equation such as $3x(y + 1)$ can be read more easily than the same idea expressed in words, such as "an unknown plus one multiplied by the product of three and a second unknown."

Tests have revealed that the number of regressions per line decreases rapidly during the first four grades of school; the next significant reduction occurs during the early high school years. Similarly, the length of pause duration of 240-250 milliseconds satisfies the perceptual demands for reading easy material by mature readers; this level is generally reached at the end of the fourth grade. Experiments comparing oral and silent reading reveal the same tendency of length of pause reduction during the first four grades, although oral reading is proportionally less effective. (3) G. T. Buswell, in his study of fundamental reading habits, concludes from a variety of experiments that there is a definite stabilization of oculomotor patterns by the end of the fourth grade. (7)

We have been surveying testing which deals exclusively with the mechanism of eye-movements. Oculomotor patterns in themselves, however, do not yield valid data in testing visual fatigue, since normal oculomotor behavior may be maintained with little or no comprehension. The determinants of visual fatigue, on the other hand, cannot be tested from comprehension capacity alone; for the physiology of eye strain is manifested only in oculomotor behavior. As we have seen in the last section, the length of reading time is not the cause of visual fatigue; prolonged reading in optimal conditions does not in itself produce eye strain. While comprehension tests are the only way to determine the quality of reading as affected by visual fatigue, examination of oculomotor patterns are the only precise way of observing the effects of visual fatigue on the motor apparatus of the subject.

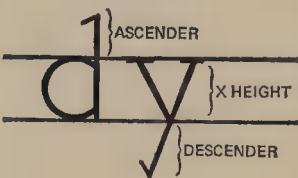
Word Perception

In the activity of reading, a group of words is perceived during each fixation pause. Since the normal reader does not sound out the letters of each word in order to read it, the next area of focus is how the reader recognizes the words he perceives during fixations. There are three main types of cues in word perception:

1. Individual letters
2. Small letter groups
3. Word shape or form

We will now investigate whether all three of these cues are equally

significant or valid, or whether one or another is a more prominent factor in word perception. In early studies, such as those by J. Zeitler (42) and R. S. Woodworth (40) it was thought that the letters with the highest cue value were the first and last letters of each word, the few letters which fall directly on the fixation point or area of clearest vision, the capitals, and the ascenders and descenders of individual letters. The ascender of a letter is that part which extends above the x height, such as in the letter "d"; the descender, conversely, is that part which extends below the x height, such as in the letter "y". These are distinguished in lower case letters.



The ascenders, or those letters which have ascenders, are the letters b, d, f, h, k, l, and t; the descenders are g, j, p, q, and y. There has been a good deal of investigation of the cue value which these letters possess; and although the significance of the ascenders and descenders in general is universally accepted, there is no wide agreement of the order of importance in which they may be considered.

Woodworth, using a tachistoscope, exposed the following seven words and had a group of subjects read them back. These were his results: (2)

Epaminondas	Epimenides
Kandelaber	Kanadabalsam
Praeglacial	Portugal
Agoraphobie	Agraphie
Hallneiutiou	Hallucination
Meludie	Medulla
Trnuhxnckt	Trunksucht

As you can see, most of the ascenders and descenders were reported accurately, although in some cases they were transposed in the words reported by the subjects. It may also be noted that the initial letter in each word is reported correctly. This, however, cannot lead to any definite conclusion for several reasons. Although they are initial letters, they are also capital letters and could support the theory that capitals possess high cue value. In words having all capital letters, however, this theory has been refuted in nearly all experiments. Furthermore, although these are both initial letters and capital letters, they also function as ascenders since the rest of the letters in each word are written in lower case; that is, they may be considered as ascenders since they extend above x height.

In 1893 Goldscheider and Muller proposed that the "determining letter," i. e., letters with highest cue value, were the initial letters, the ascenders and descenders, and the vowels. (16) This introduces the idea of vowels as having high cue value. Most studies have refuted the concept that vowels are generally significant in cue value, although we shall see that certain vowels are consistently predominant in legibility tests. Consider, however, the frequent confusion of such words as "these" and "those," "draw" and "drew," and so forth. Goldscheider and Muller claimed that perception based on word shape was possible but not the rule.

In 1928 Crosland and Johnson experimented with nonsense words to ascertain the factors behind cue value. (8) The advantage of nonsense words in such testing is that the possibility of recognizing words by their shapes is eliminated from the experiment. Their results showed that although initial letters were correctly reported (using the tachistoscope technique), ascenders and descenders were not significantly read correctly more than other letters, nor were the vowels more frequently read accurately. While initial letters are accurately recorded in all such experiments, there are two theories accounting for this phenomenon. One, advanced by Pillsbury suggests there is a general tendency of the subject to read through the word from left to right, which therefore gives the first letter of the word a more prominent part in the recognition of the word as a whole. (28) A second theory is that initials, as well as finals, are recognized because they are free on one side from the masking effect of adjoining letters. For example, in the following two lines, focus on the "o" in the central column:

b	o	n
gbe	o	lnp

The "b" and "n" in the first line are clearly grasped, whereas in the second line they do not tend to be perceived as readily.

A great deal of study has concentrated on the order of importance of letters determined by their legibility. Since nearly every test tends to produce its own variation, it would be pointless to repeat a series of results here. In all tests, however, letters of highest legibility include c, e, i, n, and a. Tinker points out certain factors which he considers significant: (34)

1. The size of the letter (such as the size of the letter "w" versus the size of the letter "i")
2. Simplicity of outline (such as the clear and simple geometric out-

line of the letter "w" versus the curvilinear complexity of the letter "a")

3. Amount of white space enclosed in the letter (such as the large closed circles of the letters "d," "p," and "q" versus letters such as "e" and "a")

Other factors which he considers will be taken up in the section dealing with typography, since they are related to the more technical design of prints such as light, heavy, and long serifs; inappropriate use of hairlines; and primarily differentiated parts of letters. It must be remembered throughout that we are dealing with letters in print rather than typescript, since most reading involves printed matter. The subject of typescript will be considered in the section on typography.

The problem of considering the legibility of individual letters is primarily the fact that reading involves perception of groups of letters in various combinations, and as it has been pointed out the ability to readily recognize or distinguish a letter is greatly curtailed by letters masking it on either side. Any further investigation of the ranking of letters in the importance of their cue value would presuppose that individual letters are the primary cue in word perception, and this has not been established by the research done in this field.

Small letter groups have been shown to serve as cues in word perception. Such groups include prefixes and suffixes, two- and three-letter blends most commonly found in our language such as pr, bl, str, and so forth; and diphthongs such as th, ph, ch, and so forth. A highly interesting experiment was conducted by M. C. Wilkins, in which she mutilated phrases or transposed syllables in common words and revealed them to subjects by means of a tachistoscope. (39)

An example of the responses follows:

<i>WORDS EXPOSED</i>	<i>WORDS READ</i>
Washout at	
Irvington	Washington Irving
Woodson	
Wilrow	Woodrow Wilson
Psychment	
Departology	Psychology Department
Renaistecture	
Archisance	Renaissance Architecture
talder	
powcum	talcum powder
Shakesbeth	
Macpeare	Shakespeare Macbeth

Davfield

Copperid David Copperfield

Her conclusion was that the cue value of small groups of letters played upon the reader's expectation of what was to follow. That is, the recognition of certain parts of familiar words, terms, or names led the reader to expect the remainder of the letters by familiar association; thus, he did not need to see the entire word in order to perceive it. This, of course, can have definite value in general reading. At the opposite extreme, however, it is not inappropriate for the reading of poetry and such prose as that of James Joyce. In such situations, though, one's rate of reading would be greatly decreased.

The cue value of small letter groups is somewhat related to the third notion with which this section was opened: the word shape or form. Here, too, the reader derives perception by expectation. Testing similar to the above example has involved words resembling other words in shape or form, such as the pattern of letters with ascenders and descenders alternating with letters of x height, but with what Goldscheider and Muller call "indifferent letters" changed, creating nonsense words. In such experiments, the exposed word was read as the expected word having a similar shape.

This phenomenon would account for such situations as inaccuracies in proofreading, where the reader must resist such cue values which lead to expectation. That such inaccuracies are not infrequent in printed texts supports the notion of the cue value of word form or small letter groups.

In the section on typography we will note experiment results which demonstrate that text printed in all capitals is read less effectively than text printed in upper and lower case letters. IT IS WORTH MENTIONING THIS POINT HERE AS ONE THEORY ACCOUNTING FOR THIS PHENOMENON IS THAT THE CUE VALUE OF THE WORD IS LOST, SINCE THE READER IS ACCUSTOMED TO SEEING THE WORD MOST COMMONLY PRINTED IN UPPER AND LOWER CASE LETTERS. IN THESE LINES YOU WILL NOTICE THAT WORD SHAPES ARE NOT AS DISTINCT AS WORDS TYPED IN UPPER AND LOWER CASE LETTERS. BECAUSE THESE LINES ARE TYPED COMPLETELY IN UPPER CASE LETTERS, THE DISTINGUISHING FACTOR OF ASCENDERS AND DESCENDERS IS LOST. In the shift to upper and lower case letters, you may notice a tendency toward easier legibility and smoother reading.

In A mOrE eXtReMe FoRm, WoRd ShApE iS HeRE bEiNg LoSt
By AlTeRnAtInG uPpEr AnD lOwEr CaSe LeTtErS. lEgIbIlItY iS uN-
qUeStIoNaBlY REdUcEd, YeT tHe OnLy NeW fAcToR bEiNg In-
TrOdUcEd Is DiStOrTiOn Of NoRmAl WoRd FoRm.

Although we have not reached any definite conclusions as to which word cues are most fundamental to word perception, we have been able so see that certain factors are unquestionably significant in legibility. The common element underlying all of these factors is visual design, whether it be of individual letters such as the distinguishable height and depth of ascenders and descenders, or the clarity of the shape of the letter "w" as opposed to such letters as "a" and "e", initial or final letters being distinguished by the pattern of ascenders, descenders, and letters of x height.

Researchers have continually related illegibility to eye strain. Legibility, we have seen, is a function of clarity of design. We have examined how this relates to word perception. The next area of study is how clarity of design improves the legibility of the printed page.

The Printed Page

"It is a mistake to think that the modern author is insensitive to the beauty of a finely designed printed page: he positively hates it."

George Bernard Shaw (5)

In books, particularly those which serve as textbooks, all graphic devices must be brought together to achieve maximum clarity and to arouse maximum interest. A well designed printed page is one which serves the text by providing maximum legibility for the reader and aids his ability to read the text. A printed page which has visual beauty may be far easier to look at than to read; above all, a page which is so self-contained by its intrinsic aesthetic decorum frequently does not invite the reader to read it. The conflict which arises between aesthetic demands and the requirements of legibility may be easily resolved by the fact that numerous studies have shown that readers equate what is pleasing to the eye with what is easy to read.

The type faces which are now available to publishers are far more numerous than those used in the past, and they greatly exceed those used in the bulk of studies on type faces. Because of the growth of typographical design in the last thirty years, as well as the growth of the publishing industry, the importance of selecting print has become a complex and imposing demand. It affects not only the printer and publisher, but the author and reader.

One factor often ignored in studies of the printed page is the intrinsic interest of the subject matter itself. Dull or unnecessarily complex text is a definite determinant of mental fatigue. But since this is a problem for authors and publishers, it is mentioned only in passing. The elements with which we will be concerned in our investigation of visual fatigue can be subdivided into six categories:

-
1. *Materials*. These are the physical components of the printed page, consisting of the choice of paper used and the ink used. These two elements will be discussed in the next section along with the use of color.
 2. *Press-work*. This is the type of printing process used, such as Linotype, Ludlow, Monotype and other *hot metal* composing machines, or the various *cold type*, or photo-composition, processes. This is primarily a printing concern, although where there is a relevance the problem of legibility will be discussed in the section on typography.
 3. *Type face*. This includes the style or design of the type, the size of type chosen, and such variants as the use of boldface, italics, capitals, condensed and expanded type. These elements will be discussed under typography.
 4. *Spacing within the text*. This involves letter-spacing, spacing between words, and leading spacing between consecutive lines of type. We will deal with some of these elements briefly in this section and more fully in the typography section.
 5. *The line*. This is one of the basic concerns of this section. It includes a discussion on the width of the line on the printed page, and the problem of justification i. e., the use of flush-right lines, as is found in most printed texts, or the use of lines which are only flush with the left column, as in typewritten pages.
 6. *Layout*. Layout means the position of the elements of the text on the page. This includes the uses of space, such as sinkage and margins and columns, the graphic design, and the general interaction of the six factors which make up the printed page.

A successfully designed printed page should encourage the reader to read it. An example of effective design can be seen in a book on book-making which avoided using the word "Preface" or "Foreword," but instead headed the preface with the words "Read this first" in red. The page was attractively laid out, and I doubt that a reader could easily avoid reading the preface, which is frequently overlooked in many books. The preface to this book was intrinsically interesting and valuable in relation to the book as a whole, which should be the requirements of any preface and unfortunately is not met by many books.

The design of the printed page must suit the text printed on it. If it is a textbook, the reader should be able to clearly follow the structure of the material, which is often set with boldface headings. He should be able to find the most significant material among the details, such as scientific principles which are frequently printed in italics, and so forth. A textbook which is clearly and systematically laid out will leave the student with a clear and systematic grasp of the material.

A piece of fiction should be laid out in such a way as to evoke the tone quality of the writing. This can be done primarily in choosing a type face whose visual design graphically suggests the literary style, and the paper should be chosen with care. A piece of sensitive prose set in heavy type on glossy paper, for example, will do no justice to its author. Similarly, it will not profit by being set in double columns, although the digest form of the novel will clearly remind the reader he is reading a digest of the original novel if it is set in double columns.

The printing of poetry, and any similar matter where word by word reading is required, must be handled with extreme care. The use of small type with broad spaces between the words provides satisfactory legibility, keeps the length of the line relatively small depending, of course, on the type of poem printed, and emphasizes the individual word unit. Similarly, with careful handling of interlinear spacing, the eye will be aided in an appreciation of the shape of the stanza. Large type would not facilitate any of these aesthetic advantages.

The amount of text per page depends partly upon the nature of the material, partly upon the length of the material, and largely upon the legibility demands. A heavy text of perhaps 1000 pages can be considerably lightened by narrowing the margins per page, but narrow margins have been shown to increase visual fatigue. The heavy text, despite the extra cost of printing 1000 pages when 800 pages could handle the material with narrow margins, would be better received by the reader than an alternative layout which would induce fatigue. The problem here is in providing an attractive and inviting cover design, a pleasing and highly legible type, and similar techniques which would create sufficient reader interest to compensate for the cost of the book.

Measure, or line width, has been the most extensive area of research in the printed page. Dearborn found that regular, uniform motor habits were more readily formed in reading short lines. (10) He found that the field of attention could be expanded more frequently and easily in such text.

Eye-voice span tests study the number of words or letters perceived during each fixation pause. The most common way of testing this is to have the reader read aloud; the experimenter suddenly covers the page and the reader continues to read, based on the number of words he perceived in the last fixation. Quantz in 1897 found that in mature readers the average eye-voice span was 7.4 words at the beginning of a line, 5.1 words in the middle, and 3.8 words near the end. (30)

The most extensive test on eye-voice span was conducted in 1920 by Bushwell. (6) He found that the eye-voice span increased from the second through fifth grades, and it was 58% better for good readers than poor readers. The average span for letter spaces were 15.9 letter spaces at the beginning of the sentence, 13.4 in the middle, and 10.9

at the end. Similar evidence corroborates the conclusion that eye-voice span decreases during the line. This serves as a strong argument against setting text in inordinately wide lines.

A second problem of wide lines is that it complicates the eye movement from the end of one line to the beginning of the next, or the return sweep. The reader finds it difficult to locate the beginning of the next line. In newspapers, where a great deal of text is set on pages considerably longer than printed books, line widths are kept short to permit the reading of each line in one or two fixation pauses and permit a minimum of difficulty in the return sweep. There has, however, been very little testing involving news print.

In 1941 Luckiesh and Moss studied the effect of line length on readability, using 10-point Texttype set in lines of 13, 17, 21, 25, and 29 picas. (21) A pica, the standard printing measure, is approximately one sixth of an inch. They found that readability was improved in direct proportion to the width of the line. They were not, however, working with lines of great width. Paterson and Tinker in 1940 studied lines of 9, 19, and 43 pica widths. (27) They found that in short lines, i.e., 43 pica widths the readers were unable to find the beginning of the new lines in the return sweep. The 19 pica width lines were found best. In the section on typography there is a table of optimal pica line widths for different sizes of type, and the appropriate points of leading.

Another consideration in laying out lines of text on the printed page is whether they should be justified or unjustified. Justified lines involve word and sentence spacing (and often letter spacing) to achieve uniform measure; that is, the line is flush with both the left and right columns, as in most printed texts. Unjustified lines are "ragged" lines, set with uniform word spacing and uneven lengths; that is, the line is flush with the left column only, as in typewritten material.

Lee (20) points out the advantages of unjustified lines, but I am not sure the only argument in favor of justified lines is that we are accustomed to it. Evidence has been found supporting the idea that clarity is an important factor in the readability of the printed page, and the use of flush-right columns (as in justified lines) contributes to this overall sense of clarity. Unfortunately, little testing has been done in this field, since few people have questioned the use of justified lines. If it is as significant an area in the study of legibility, or readability, as Lee suggests, testing is needed.

In considering each of the factors that make up the printed page, it must be remembered that none of them exist in isolation. Every item on the printed page must lead to a sense of clarity and uniformity of taste of the whole. Two different type faces, which in themselves may have been selected for particular legibility, may not work harmoniously

together on the same printed page. The same must be said of all other elements on the printed page.

The basic conclusion we can derive from the available material is that the most important consideration in the printed page is legibility, and this should be the determinant of the aesthetic appeal of the page. The factors in legibility involve clarity of individual items as well as the uniform effect of these interacting elements on the printed page. Lines set in short widths do not permit readers to make maximum use of horizontal perceptual cues, while lines set in very long widths make the return sweep difficult as well as do not allow readers to make maximum use of the greater eye-voice spans of fixations at the beginning of lines.

The ultimate decisions must follow the criterion of what serves the particular text most effectively. A printed page which is visually beautifully designed but which is not designed according to the demands of the text is actually a poorly designed page.

In the next section we will deal with other factors of the printed page; the use of paper, ink, and color.

Physical Contrasts:

Paper, Ink, and Color

In the last section, "materials" were listed as one of the elements of the printed page; and it was mentioned that these included paper and ink. In considering these elements we will also consider the effects of color since all three involve the study of contrast as a determinant of legibility.

M. Luckiesh and F. K. Moss in 1941 experimented with the visibility of print on various qualities of paper. (23) In their tests, they used nine different types of paper, each varying in its degree of whiteness. They found that flint enamel, which is highly glazed paper, significantly retarded reading. This type of paper, they found, is subject to glare when the illumination of the reading situation is not well diffused. In the conclusions derived from their study they emphasized two points:

1. Rough surface paper is the best to use in printed material, since it is the least subject to glare.
2. Whatever paper is used must be thick enough so the shadows from the print on the reverse side of the page do not show through, since this is a definite contributing factor to visual fatigue.

The first definitive monograph on the effects of paper surface was R. L. Pyke's REPORT ON THE LEGIBILITY OF PRINT in 1926. (29) His conclusions were similar to those in Luckiesh and Moss's later study. The minimum thickness of paper, he stated, should be

0.075 millimeters in thickness, since print on the reverse side will not cast visible shadows on paper meeting this requirement. He also emphasized the importance of a mat, or rough, surface; and he further specified that the surface should be hard, though neither glazed nor ribbed. As for degrees of whiteness, it should be as white as possible without having a glow.

Some later experiments, such as Webater and Tinker (37), Paterson and Tinker (26), and Stanton and Burt (32) have discounted some of these fine points, stating that the only important factors are the thickness of the paper and the absence of gloss; in the subject of glossiness, furthermore, they claim that glare can only be attributed to a lack of uniformly dispersed light producing specular reflection.

Most book paper currently used reflects 75%-85% of light. Ink reflects approximately 5% of light. There is thus a difference in reflectance, or brightness contrast, or 70%-80%. This has been determined as an effective contrast. Although inks do not vary greatly in their degrees of light reflection, the problem of inks is that they must be suited to the type of paper being used. As new paper-processing techniques develop new products, such as coated surfaces, varying degrees of hardness and porousness, new inks must be developed to suit them. This, however, is primarily a printing problem.

Reflectance, or brightness contrast, is the most significant factor in legibility of print on paper. Various experiments have been conducted to test the different effects of tinted paper and colored ink. Tests have also studied the effects of white print on dark backgrounds. D. Starch found that black print on white background was read 42% faster than white print on a dark gray background. (33)

In 1965 Tinker reported a study of the relative legibility of print in eleven color combinations. (34) First, he used text printed in black jobbing (standard black ink) on white (light grayish-white) paper, which he set as the standard for legibility. Next, he tried grass green (a dark green ink) on the same white paper. This, he found, was 3% less legible. Lustre blue, a dark blue ink, on the same white paper was 3.4% less legible than the black jobbing on white. Then he tried black jobbing on yellow with a slight orange tinge paper, which proved to be 3.8% less legible. Tulip red, a light red ink, on white paper was 8.9% less legible, although on the yellow paper it was only 4.8% less legible than the black on white.

Grass green on red, a dark tint, paper was 10.6% less legible; chromim orange, which is actually a dark lemon yellow ink, on black, dark grayish black, paper was 13.5% less legible; while chromium orange on white was as great as 20.9% less legible. This last color contrast, however, was complicated by the fact that the chromium

orange on white appeared as a light orange, which provided less contrast than on the black, where it turned out to be a dark lemon yellow.

Next, he tried the tulip red on green paper. Here the tulip red appeared as a dark brown ink, whereas it was a light red on the yellow paper; the green tint was a dark green. The legibility in this case was 39.5% less than the black on white. Finally he printed black jobbing on purple, a dark tint, almost violet paper, and attained his maximum illegibility in the test of 51.5% lower than the black jobbing on white.

These percentages in lessened degrees of legibility can also be read as lessened degrees of contrast. The most significant factor in all physical contrasts, including the type and tint of paper used, the ink, and any use of color in printed material is the contrast. It may be concluded that the greater the degree of brightness contrast without producing glow or glare, the greater the degree of legibility.

Typographical Factors

We now come to what is probably the most important single factor in the subject of legibility, and, therefore, visual fatigue. Typographical factors include the different type faces, the size of type face used, variations within each type face: Roman, italic, boldface, condensed, and expanded; spacing, leading, letter-spacing, indention, and all the factors which make up composition.

Composition refers to the actual transformation of the original copy usually typescript into a form suitable for printing or for making printing plates. The compositor is the person who effects this transformation.

Presently there are four methods of setting type:

1. Setting metal type by hand—a slow method in which each character or piece of type, is selected from the appropriate cases and arranged in lines of type ready to be printed.
2. Setting metal type by machine—similar to the above, with the only difference being that the compositor uses a keyboard much like a typewriter and a machine selects the characters from their cases.
3. Typewriter composition—the compositor types the line of text on a keyboard, which automatically justifies the lines if required (that is, spaces them to a required measure, or width) and the line is then cast in hot metal according to the appropriate type face; thus, each line of type is cast fresh and then melted down after it is used. In the first and second method, type is reused and stored in cases; and
4. Photographic composition—a wide variety of techniques which are variations on the typewriter composition method, except the line

of type is photographed instead of cast in metal type. This is called *cold type* as opposed to hot metal composition.

Basically, these are printing matters. However, in one respect they do concern the problem of legibility. The third process, typewriter composition, involves casting each new line of type freshly as the line is set. The advantage of this is that the characters are clean, clear, and fresh. Processes where the same type is used and reused, as in hand or machine composition, risk the gradual dulling of the type face. The typewriter has the same disadvantage. Photo-composition, of course, shares the advantage of clarity with typewriter composition since the shape of the letter is photographed rather than printed; therefore, it cannot dull with use. The most common processes of typewriter composition are Linotype, Ludlow, and Monotype.

Typographical decisions prior to 1900 were based on casual observation, considering aesthetic appearance, economy of space, and traditional practice. Since 1925, however, there has been a great deal of study involving the legibility of type. There are six common ways of investigating the legibility of print:

1. Visibility measurement scores—this method tests the legibility of isolated words, letters, and symbols, but not the effects of type size, line width, and leading, i.e., interlinear spacing.
2. Distance method—this tests the distance from the eyes at which print can be perceived accurately; the results of such testing are similar to the above method, and again fail to take into consideration the effects of specific elements.
3. Short exposure method—this is usually conducted using a tachistoscope and tests the quickness of perceiving printed symbols; it, too, tests the combined effects of typography and fails to focus on specifics.
4. The blink test—this method is based on the hypothesis that the rate of involuntary blinking is inversely related to the ease of seeing; numerous studies, however, question the validity of this method.
5. Rate of work—this method tests the speed and accuracy of performance under specific conditions, such as variations of type sizes, type faces, leading, and so forth; it is the most valid and most common form of testing.
6. The rate of work method combined with an analysis of eye movements—this combines qualitative and quantitative performance based on comprehension and physiological factors.

The results of many experiments have shown that relatively short periods of work yield valid legibility scores. This supports the con-

clusion stated earlier that visual fatigue is not due to prolonged visual activity alone (under optimal conditions), but is a function of illegibility in some degree.

The first typographical factor we will consider is the type face. This refers to the style, or design, of the type used. All the characters within a single type face are called a *font*. The font includes the complete alphabet in upper and lower case Roman letters the style used in this typescript, for example, italic letters, boldface letters, the complete series of small capitals, and numbers and punctuation in Roman, italic, and boldface.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz,.;'!-?1234567890

Among the general findings in investigations of the effects of different type faces and styles on legibility, it has been determined that text set in all capital letters is less easily read than material set in upper and lower case letters, such as this paper. Excessive use of boldface similarly retards reading, as do large amounts of text set in italics. However, the use of italics for a great quantity of printed text has been effective in certain instances. Two that come to mind are Paul Gallico's novella THE SNOW GOOSE and James Agee's A DEATH IN THE FAMILY. In the former work the entire novella was printed in italics, which caught the delicate, sensitive mood of the piece quite effectively without producing significant eye strain at least, not noticeably. In the Agee novel, the "memory" chapters were printed in italics; the effect, similar to that of the Gallico work, successfully interrupted the present continuum of the plot in its starkness by catching the tender and poignant childhood reflections of Rufus, the son of the protagonist. While the major portion of a A DEATH IN THE FAMILY was printed in Roman type, it is significant to note that the italic type of THE SNOW GOOSE was a larger type size than similar texts use, and the leading was considerably greater than type normally demands.

Nevertheless, italic and boldface type is used effectively for a few short lines of significant matter, since it turns the effect of retarding the reader to its advantage; that is, it provides its own justification by utilizing the reader's increased attentiveness to such passages. Prolonged use would, generally, develop into a state of fatigue for the reader because of the strain exerted in the increased attentiveness.


Tinker and Paterson studied texts printed in ordinary lower case versus boldface lower case, and lower case versus upper case. (36) Their results confirm the above conclusions that boldface and all upper case text is less readable than ordinary text. But they further conclude that readers place high aesthetic value on those printing arrangements which appear most legible; thus there is strong agreement between

judged legibility and judged pleasingness. This is a conclusion we have seen expressed earlier.

As to the actual preference of one type face over another, however, there is some disagreement among investigators. Tinker lists the following ten type faces in order of legibility based on 1932 data: (34)

1. Cheltenham
2. Antique
3. Bodoni Book
4. Old Style
5. Garamond
6. American Typewriter
7. Scotch Roman
8. Caslon Old Style
9. Kabel Light
10. Cloister-Black

Cheltenham features wide, squat, heavy letters with small serifs, the short lines stemming from, and at angles to, the thin strokes of letters;

e. g., . Antique features similar attributes, although the letters are somewhat less squat. The advantage in clarity of these two type faces is, primarily, the large counters, or white inner spaces such as in the letters "e", and "a", and so forth. Bodoni Book, has letters which do not exhibit marked squatness. The effect of several sentences of type is more staccato than fluid in this type face.

Old Style is a somewhat lighter type face than Bodoni Book, but otherwise similar in design. Garamond, is better spaced than the above styles. The letters appear to be wider, but in effect they are narrower. This is largely because they have a smaller x-height. The disadvantage of American Typewriter, is the clumsy serifs and the poor spacing between letters.

Scotch Roman is a standard type face which has a small x-height and an old style design. Caslon Old Style is a heavy and tight type face, but one which the British Association Committee recommend most highly. Kabel Light is similar to the Trade Gothic Light. The letters are thin, have a large x-height, and no serifs. Cloister Black, similar to Old English, is clearly the least legible because of its highly ornate design which tends to obscure the distinctive form of each letter. It produces greater fixation frequency.

Tinker points out in his study that mixing type forms within one passage of text slows the reader's speed.

Sir Cyril Burt found that although the British Association Committee gives preference to Caslon, Old Style Antique and Imprint (modernized versions of Caslon) are the most legible for a wide range of

printed matter, from children's books to adult reading material. (5) Old Style Antique is characterized by broad alphabet letters, distinct shapes, serifs, and high shading of curves and strokes. All elements contributing toward distinctiveness of shape tend to increase legibility. Burt points out that modern faces are the least legible. Older faces accentuate those points that are different among letters, while the modern faces accentuate the similarity. This leads to confusion of such letters as "n" and "u" which in many modern faces are purely inversions of one another. Compare, for example, the distinguishing use of serifs in these two letters in Bodoni Book and Garamond, as opposed to the more modern and less distinct Trade Gothic Light. The old oblique shading of letters, Burt points out, is pleasanter to the eye and easier to read. But he does say that certain modern faces have the advantage of larger counters than in older faces; in the older styles such as Baskerville and Caslon, he notes, the "e" and "c" are easily confused because of the small counters. Both Burt and B. Zachrisson (41) found that readers prefer typeface that appears to border on bold-face with the exception that extreme forms of this produce closed counters. Tinker confirms their opinion. Zachrisson, however, claims that in his studies he found that most of the type faces in common use are equally legible, irregardless of the use of serifs; only Cloister Black and American Typewriter significantly retard reading.

Amid the wide disagreement on type faces, the only general conclusions seem to be that distinctiveness of shape is the most significant factor. This can be determined by the use of shading, form which is neither overly vertical nor horizontal (not including such variations as condensed and extended type faces, which are a special case: see the example below,) large counters, and most experimenters include the use of distinctive serifs which aid horizontal eye movement without encumbering the shape of the character.

18—STANDARD LIGHT

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz

18—STANDARD LIGHT EXTENDED

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz

The two examples are both Standard type face of the same size (18 points). The differences, as can be seen, are only in the widths of the letters. Full texts are rarely printed in condensed or extended variations, although they may be used effectively in headlines and titles.

There are also further variations, such as extra condensed or extra extended. Even regular faces of the same height may have varying widths, discounting condensed or extended variations. This is an important consideration in selecting type faces, and publishers often measure characters by the width of the entire alphabet in one type face as well as by their height. French children's texts are often characterized by narrow type faces, giving rise to the term Continental Style. The American Style refers to wider type faces, since there is a common tendency to print children's books in such type faces. These terms are more common in British publishing usage than in American. Studies have shown, however, that the wider type face does not tend to aid reading ability in children. Word form suffers distortion, particularly when a large type size is used. There is also the problem that line width has to be extended or the number of characters per line has to be reduced. In either case, the child is not able to take full advantage of his fixation pauses; he will either need an additional pause per line and as we have seen before, the ability to perceive large groups of letters diminishes towards the end of each line of print or he will perceive less words in the same number of pauses per line.

There has been much study as to the efficacy of serifs. The newer type faces, such as Tempo or Futura, discard them. Old Face types are characterized by serifs. While Zachrisson found that in his experiments there was no significant difference in legibility between Old Face and Sans Serif type faces, (41) most investigators have reached the conclusion that serifs definitely increase readability. Some type faces, however, have heavy or clumsy serifs. But those which use them effectively help to distinguish the individual shapes of the letters. In addition, the horizontal plane in which serifs lie encourage the eye to move horizontally across the line of print. This improves the rate of reading. There is also greater definition of word form when serifs are used, and word spacing is immediately more distinct without having to be increased.

The greatest amount of research in typography has been done in the field of type sizes. Type size is the distance from the top to the bottom of a type face, including the highest and lowest ascenders and descenders respectively. You will remember that the x-height of different type faces may vary although the type size is the same. This is a

abcdefghijklm } TYPE
SIZE

significant factor since a type face with a large x-height will often seem to be a larger type size on a printed page than a type face with the same size but a different x-height.

The pica unit of measure, as has been mentioned, is about one-sixth of an inch. Since there are twelve points to a pica, there are approximately 72 points to the inch. The point, however, is actually 0.01384 inches; therefore, there are actually 76 points to an inch. The 72 points approximation is generally used in measuring layout of lines, leading, and spaces.

While most experimenters consider type size all-important to legibility studies, particularly involving children, Gilliland claimed that type size was not an important factor at all in children's reading. (15)

B. Zachrisson found that children preferred 16 points type over 10 and 14 point type in the first grade; in the fourth grade 12 point type was preferred over 8 point type in the ratio of 3:1 (41) McNamara, Paterson, and Tinker experimented with 3,050 pupils using 8, 10, 12, 14, 18, and 24 point types. (24) They found that there was no differential effect of type size in grades 1A and 2B, both preferring 18 point type. In 2A, there was a slight preference for 14 point type. In 3B, 10 and 12 point types were favored, although 14 point type was nearly as good. Tinker found that in children's books 14 to 18 point type was best for grade 1; 14 to 16 point type for grades 2 and 3; 12 point type for grade 4; and 10, 11, and 12 point type for grades 5 through 8. (34) He pointed out that 12 point type is most commonly used beyond third grade.

The factor which is tested along with type size is leading. Leading, is the amount of space between lines. This is measured in points. It must be emphasized that although tests correlate leading to type size, different type faces of the same size may require different points of leading. In the comparison of Trade Gothic Light and Scotch type faces, there appeared to be more interlinear space with the Scotch sample because of its smaller x-height.

Bentley found that speed was increased with each addition of leading up to 7 points and then declined rapidly. (4) Material set *solid* was read relatively slowly. Solid means there is no leading; that is, the descenders of one line and the ascenders of the following line have no space between them. This is not as difficult to read as it may sound, because descenders and ascenders rarely happen to fall directly above and below one another. This conclusion is universally accepted, though it is generally taken to refer to type faces with large x-heights. Trade Gothic Light would be difficult to read with no leading, while Scotch would not seriously suffer.

Tinker found that fifth and sixth graders required more leading for 12 point type than seventh and eighth graders. (35) After sixth grade the leading demands were the same as for adults. Tinker has drawn up the following chart, which concurs with the conclusions of most investigators: (34)

POINT TYPE	PICA LINE WIDTH	POINT LEADING
6	14	2-4
	21	1-4
	28	2-4
8	14	2-4
	21	2-4
	28	1-4
	36	2-4
10	14	1-4
	19	2-4
	31	2
12	17	1-4
12	25	0-4
	33	1-4

For elementary grades, he concluded, 6 to 8 points were needed in the first grade; 4 to 6 points in the second; 3 to 4 in the third and fourth grades; and approximately 2 points were sufficient thereafter.

The conclusions of these studies suggest that Old Face types are easier read than Modern Faces; serifs, if they are not heavy or too ornate, are preferable to Sans Serif type faces; 12 point type is optimal beyond the fourth or fifth grades and thereafter; and a range of 1 to 4 points of leading is quite sufficient.

The Reading Situation

The final factor which must be considered in the study of visual fatigue is the reading situation. This includes the optimal position, or degree of slant, of the printed page while reading; the distance at which the book should be held for clearest vision; and the proper illumination for reading in different situations. In many cases, these factors can be the most prominent in causing visual fatigue.

Study has been more conclusive in these areas than in the realms of word perception and typography. Therefore, it will not be necessary to examine various experiments to evaluate various results.

Research in these fields has been collected in Tinker's BASES FOR EFFECTIVE READING. This is the most recent and comprehensive study published in the field of visual fatigue. A summary of his conclusions follows:

Position of the Printed Page. The printed page is read most effectively when it is on a plane perpendicular to the line of sight, or visual axis. This plane is generally about 45 degrees up from the table top or the desk top. The significance of this has been effectively tested. Tinker has found that a deviation of only 15 degrees either way

definitely interferes with easy and fast reading. There is a 10.7% retardation of reading speed when the printed page is held on a plane beyond a 45 degree angle, and a 16.4% retardation beyond 60 degrees.

Distance of Printed Page. When a child begins to read print, he should be able to focus his eyes for clear vision at a reading distance of 12 to 18 inches (near vision) and 20 feet (far vision). That is, he should be able to focus clearly within this range as it represents general working distances. The normal reading distance is approximately 14 inches from the eyes, or within a range of 10 to 18 inches.

The eyes must be able to adapt for effective seeing when the intensity of illumination varies, and they must maintain good muscle balance in order to achieve single vision. When co-ordination is faulty, the reader will begin to see double images. This is one of the reasons why studies of eye movements must include measurement of the efficiency of both eyes simultaneously, since lack of co-ordination which would not show up in studies checking the movements of one eyeball, as was done in early research would lead to visual fatigue.

Children are naturally born far-sighted, and studies have shown that the ability to focus properly for clear vision within the range indicated above is often not developed until seven or eight years of age. However, Davidson has proved that children four years or younger can learn to read without harm to their eyes. (9) In Great Britain, for example, reading is taught at five years of age without causing harm to the ocular mechanism.

Illumination. The unit of measurement used in determining illumination situations is the footlambert (fL), which is also called the *footcandle* (fc) or the equivalent *footcandle*. The footlambert is the light intensity upon a surface perpendicular to the light rays from a standard candle at a distance of one foot. That is, it is the light intensity on a small area of surface when an ordinary candle is held vertically above the surface at a distance of one foot.

In 1915 the Illuminating Engineering Society began issuing codes for lighting standards. Below are the current lists, with a comparison between the American code and the British code:

<i>Situation</i>	<i>American Code</i>	<i>British Code</i>
Home: prolonged reading	30 fL	15 fL
study desks	70	15
Office: regular work	100	20
ordinary reading	30	15
Library: reading tables	30	15
study area	70	15
School: reading area	30	15
Drawing:	100	20

Tinker also adds some statistics based on type size in different situations. Sustained reading of 10 to 12 point type requires illumination of 15 to 25 fL; print 7 to 8 points requires 25 to 35 fL. In ordinary schoolrooms, he feels, 20 to 30 fL are sufficient. Casual reading of book-sized print requires 10 to 15 fL, while smaller print demands 15 to 20 fL. When there is a medium brightness contrast between the print and the paper, 35 to 50 fL are required; 75 to 100 fL are needed when there is a low contrast, though this situation is uncommon. (You will recall that standard brightness contrast is approximately 70% to 80%.)

These considerations are generally taken into account in public buildings, such as schools and libraries, and modern offices. However, they are ignored too often in the home. A common instance is the watching of television without adequate lighting in the room. While this is not exactly a reading situation, the attentive focusing required needs considerably more light than that produced by the television alone. It is not uncommon for adults to decide to watch television until they become "sleepy." What they are actually referring to is a condition of visual fatigue, which may be harmful to the visual mechanism after prolonged repetition. Such situations must be guarded against in order to preserve eyesight.

Conclusion

Visual fatigue is that state in which the visual mechanism, after operating in less than optimal conditions, ceases to function with maximum efficiency. In the reading situation, this is characterized by increased number of fixations per line of print, more regressions per line, slower rate of reading, less accuracy, and diminished comprehension. Research in the field of visual fatigue and work decrement has been undertaken seriously since the end of the last century and more significantly after the turn of the twentieth century, particularly after 1920. The best methods of testing combine the study of eye movements with reading rate and comprehension tests.

The determinants of visual fatigue are conditions of illegibility, rather than mere prolonged visual activity. Illegibility can be generally classified in two categories: (1) stemming from the printed page itself, and (2) deriving from the environment.

In the first category, studies in word perception have determined that reading is aided by certain perceptual cues, such as individual letters (among which initial letters and final letters, ascenders and descenders, and letters with large counters or enclosed white space are thought of as probably most significant), groups of letters (which lead to the recognition, or preconceived notion, of ensuing letters), and word form. Illegibility, then, is any condition which tends to interfere

with the effectiveness of these cues, particularly lack of distinctive and distinguishing shape (whether in individual letters or within the word as a discrete unit).

The effective layout of a printed page should provide maximum clarity for the material printed on it. Uniformity of type design, effective use of space, and similar graphic devices help to achieve this. There should be the highest degree of brightness contrast between the color of the ink and the tint of the page without producing glow or glare. Black jobbing on white unglazed paper with a rough, hard surface and a minimum thickness so as not to allow shadows from the print on the reverse side best achieve this.

The type face used should have letters of easily distinguishable shape; certain Old Faces with appropriate use of serifs are preferred. While optimal type sizes vary according to the nature of the material being printed, the age level of the reader, and the design of the type face, ordinary books are most legible when the type size is approximately 12 point; 1 to 4 point leading is preferred. These conditions are satisfactory for readers beyond the fourth grade level, including adults, since it has been found that at this level reading habits reach "maturity," with an occasional slight development during the high school years. Line widths of approximately 19 picas make maximum use of oculomotor patterns, although specific line widths must be determined by the nature of the material.

In the second category, or factors of illegibility stemming from the environment or reading situation, the most significant is the degree of illumination. For the ordinary reading situation, an intensity of approximately 25 footlamberts (fL) is adequate.

This summary of various conclusions is, of course, very general. They could not be applied to all situations; else there would be only one choice to make in printing and in reading: legibility *or* variety. Fortunately, this is not so. All decisions relating to reading matters must stem from the material and situation under consideration. However, the one criterion that can and should be applied to all situations is legibility above all else. Extensive and intensive concern with the optimal conditions of legibility is the most effective way to combat visual fatigue.

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Educational Implications of Glandular Malfunctioning

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I. *The Endocrine System*

Although the concept of endocrine malfunctioning has appealed to the public entirely out of proportion to the cases of glandular disturbances or the possibility of therapy (28), teachers need to understand that the endocrine system does play an important part in human growth and development. The glands function in close relationship with each other affecting the whole body. Temporary imbalance can occur, especially in children, and such disturbances can also clear up spontaneously without treatment. Between the ages of nine and seventeen years, a large proportion of patients visiting an endocrine clinic have no specific glandular lesion, but they merely display variations in the time or pattern of adolescent growth and development. (46) This discussion, then, will be concerned with a description of the six important glands of the endocrine system, their functions and dysfunctions, and the educational implications of endocrine disorders for the secondary school.

The endocrine system is made up of ductless glands which empty their secretions directly into the blood stream. These secretions, called hormones, have specific effects on growing tissue. The blood in turn distributes the hormones to all parts of the body, where they affect cells, tissues, organs, and systems that may be a distance away from the glands themselves. In this manner the endocrine glands are similar to the nervous system because both affect many organs. Some glands function at all times, some during certain years, and some only once. Generally, a diagnosis of glandular malfunction is difficult and involved.

Extremely powerful chemical substances, called hormones, are manufactured by the endocrine glands from raw materials such as protein and iodine, supplied by the food eaten. Waste hormones are eliminated through the kidneys into the urine. The two types of hormones are those that act upon tissues and organs outside the endocrine system and those that maintain the balance within the system. Body func-

tion, growth, physical appearance, mind, learning capacity, and emotions are strongly influenced by those hormones.

Because the glands are closely interrelated, when one is malfunctioning it can cause a series of problems to the extent that even endocrinologists are very careful when diagnosing and treating disturbances of these glands. (45) According to Eames the ability of a child to learn is strongly influenced by his endocrine glands, but the relationship between this aspect of the child's physiological make-up and his activities in the classroom needs further investigation, although it may require work in a medical laboratory, which is beyond the resources of many educators. (13)

Endocrinology texts and reports establish the relationship between endocrine balance and normal growth. During childhood, endocrine disturbances are accompanied by such severe physical abnormalities that laymen and doctors, forgetting other influences on growth and development, tend to suspect an endocrine dysfunction where one doesn't exist. In fact, rarely are there serious endocrine problems which require hormone therapy or other treatment.

Although teachers in the classroom will never be involved in the actual diagnosis or medical treatment of endocrine patients, school personnel will need to understand some of the manifestations of malfunctioning conditions. Studies show that healthy children are consistently more successful in school than are children in poor health. (5) Whatever information a teacher can accumulate about his students, the better he can teach them.

II. *The Glands and Their Functions*

A. *The Thyroid.* The thyroid gland, located in the neck below the larynx, is composed of two lateral lobes connected by an isthmus. A colloid inside the gland releases the hormone thyroxin into the blood as needed. When circulating thyroid hormones decrease in quantity, thyroid stimulating hormones output increases causing the thyroid gland to secrete more; increased levels of circulating thyroid hormones depress thyroid stimulating hormone production and thus reduce thyroid activity to normal.

Functions of the thyroid glands include storing thyroglobulin, an iron-containing protein, and production of thyroid hormone which stimulates metabolic rate of cells thus influencing physical and mental development, advent of sexual maturity, and other processes.

When there is insufficient iodine to produce thyroxin more thyroid stimulating hormone is secreted causing an enlarged thyroid gland or goiter. The goiter makes it possible to use iodine more effectively. Endemic cretinism is often found in children whose mothers had endemic goiter.

Two common diseases of the thyroid with opposite symptoms are hyperthyroidism or exophthalmic goiter, caused by excessive activity of the gland, and hypothyroidism caused by deficient activity of the gland. Hyperthyroidism which occurs most frequently during puberty and menopause has the symptoms of weight loss, fatigue, extreme nervousness, irritability, emotional instability, fast heart rate, high basal metabolic rate, sweating, protruding eyeballs (exophthalmos) and startled appearance. Also there are a number of eye changes which sometimes occur like infrequency of blinking, lid lag, failure to converge, and failure to wrinkle the brow when looking up. Sometimes there are hallucinations and psychotic manifestations. Mild hyperthyroidism does not always include the characteristic protruding eyeballs, but other symptoms of the disease may be present. Emotional shock can trigger hyperthyroidism. According to Dr. Blizzard of Children's Hospital of the District of Columbia, children who are treated early for this disease may develop normally physically but may not have normal mental development. (5)

A person with myxedema, the common hypothyroid condition, may have significant mental problems such as psychoses, or in less severe cases, poor emotional control. The symptoms of borderline myxedema cause the patient to be apprehensive, faultfinding, nervous, and even the basal metabolic rate (BMR) becomes unreliable.

In 1955, 79 people with severe congenital hypothyroidism were studied for mental development. Twenty-nine were treated during the first year of life and 12 of these had an IQ over 90. Of the other 50 patients treated after age one, none had an IQ over 90. The children with adequate treatment who failed to respond mentally had severe hypothyroidism in utero. In a second group of 32 patients who developed symptoms of cretinism between ages six months to two years, 13 had an IQ of 90 or more because their thyroids functioned somewhat during infancy. (18)

The people who suffer from a malfunctioning thyroid gland usually look peculiar in some way—skin, hair, eyes, etc.—and this can have a very harmful effect especially in a child. Many of the defects can be cured by drugs or surgery, but while the symptoms exist the child must adjust to them although he frequently does not feel well.

B. The Pancreas. The pancreas forms a digestive juice which discharges just beyond the stomach into the bowel, and provides insulin which is secreted into the blood, thus regulating carbohydrate metabolism. The digestive juice of the pancreas is formed throughout the whole gland, whereas insulin is produced only in the beta cells of the islands of Langerhans which together form the gland.

The major disease of the malfunctioning pancreas is diabetes mellitus, which is caused by the hyposecretion of insulin. The three most

important etiologic factors in diabetes are obesity, heredity, and possible disturbances of other hormones than insulin. (23)

There are three classes of diabetics; juvenile diabetics who get the disease before age twenty-five, adult diabetics who get the disease after age twenty-five, and miscellaneous types of diabetics who may have the disease only temporarily. Children are called "brittle" diabetics because their disease is difficult to control and they must always inject insulin, but adults are usually "stable" diabetics.

Early symptoms of diabetes include increased quantity of urine, thirst, hunger, and weight and strength loss. Of the many symptoms of the disease, the diabetic coma is the worst. Other important symptoms include skin changes, blurred vision due to disturbances in accommodation, constipation caused by dehydration and dizziness due to loss of circulating blood volume. After many years with the disease other complications appear like large fatty liver, cataracts, diabetic retinopathy, diabetic nephropathy, atherosclerosis, neuropathy, and gangrene. Diabetics are more likely to get infections too. These symptoms and complications are controlled by careful management of diabetes and usually by administration of insulin.

Hyperinsulinism or "insulin shock" is the other important disease of a malfunctioning pancreas. It is caused by hypersecretion of insulin which in turn lowers the blood glucose level (hypoglycemia). When the hyperinsulinism is due to tumors of the islet cell, attacks may become severe even to the point of convulsions or loss of consciousness. Long periods without food combined with exercise may bring on attacks with such symptoms as fatigue, weakness, faintness, nervousness, nausea, and sweating. This frequently occurs in the morning. More severe symptoms include irritability, confusion, double vision, involuntary movement of the eye, aphasia, mania, convulsions, unconsciousness, and coma. People with this disease show personality changes and often become obese because of frequent eating to prevent attacks. The cure for this disease is surgical removal of the tumor.

That diabetics have adjustment problems is attested to by studies from Dr. Field's clinic where he found 40% of diabetics had somewhat severe psychological and social problems. He says that as a group diabetics have a marriage rate 10% less and a scholastic achievement rate of 15% less than other people, and they have a more difficult time finding good employment. (16)

Adolescents have a more difficult time with diabetes than younger children, and in all children emotional conflicts make diabetes more difficult to control. Here are some problems that the child faces: he feels different from his peers and may cheat on his diet to be like them; he does not like having to stick to his diet and having to inject in-

sulin; he is afraid of insulin reactions; he dislikes daily urine testing, and he often fears the late complications of diabetes. (3)

C. *The Pituitary*. The most remarkable of these ductless glands is the pituitary which, in its only function, produces more hormones than any of the other glands. This tiny reddish gland, sometimes called the "master gland," has greater weight in the female. It is located in the base of the skull.

Malfunctioning of the gland can cause the following:

1. Growth abnormalities such as dwarfism, giantism, and acromegaly, a condition whereby the jawbone, cheekbone, bones over the eyes, and bones in the hands and feet are enlarged.
2. Diabetes insipidus, which causes excessive urination and water intake, and lack of control of urination in small children. It is usually of short duration.
3. Cessation of skeletal and soft tissue growth.
4. Hypertrophy of liver, spleen, and kidneys.
5. Atrophy of the thyroid, adrenal and gonads.
6. Decreased life span.
7. Decreased resistance to infection.
8. Gastrointestinal disturbances and low blood sugar.
9. Poor metabolism because the pituitary regulates metabolism directly or by means of regulating other glands. By acting on the thyroid gland it regulates the amount of oxygen consumed by the body tissues and thereby the amount of food burned.
10. Slow growth. People with pituitary dwarfism may be either of normal or of subnormal size at birth; growth is slow but may continue for several decades. Parts of the body remain infantile in appearance but people affected with this disorder mature sexually at a normal rate and give birth to normal sized children.
11. Cushing's disease is caused by a tumor. Its symptoms are obesity of the abdomen, face and buttocks, but not of the limbs; facial and hand skin becomes excessively red; there is profuse growth of hair; bones become brittle; and sexual functions are suppressed or at a low level.
12. Simmonds' disease in which the person appears to age considerably, becomes emaciated, loses hair, teeth and finally mental functions.
13. Frolich's Syndrome causes the person to become excessively fat and have infantile sex organs. For the child it indicates dwarfism, mental laziness and a voracious appetite. In adults, males become effeminate and females extremely obese. There may be moderate to mild mental retardation.

D. *The Gonads*. In direct relationship to the pituitary functioning

is the functioning of the gonads, a general term referring to both the male sex glands, or testes, and the female sex glands or ovaries. The gonads are the reproduction glands which produce female and male hormones. The sex hormones regulate the functioning of the sex organs. Steroids, the fatty compounds found in the hormones, are poured directly into the blood stream and affect the voice, hair growth, breast development, shape of the pelvis, and distribution of fat.

The most common malfunctioning with which educators come in contact is the menstrual cycle malfunction. Since sex hormones regulate menstruation, the female sexual cycle is a complex hormonal mechanism. Excessive menstrual flow may cause anemia, but even with normal flow there are definite personality changes preceeding the flow; and the nervous system is affected. It is difficult to separate the endocrine system from the nervous system at this point. Pre-menstrual tensions often affect conduct. Menstrual disorders are often signs of other malfunctionings and should be referred to a physician. The common symptoms of the menstruation cycle culmination are headaches, irritability, nausea, pain in the lower back and legs; sometimes menstruation fails to appear in the adolescent and could be due to anemia, underdeveloped womb and ovaries, tuberculosis, malnutrition, or excessive reducing diets.

E. The Parathyroid Glands. The parathyroids are four small reddish brown glands attached to each of the four back corners of the thyroid gland. The parathyroids are not necessary for life; their only function is the secretion of the hormone parathormone, which acts to keep a balance of the electrolytes in the body fluids, and influences the calcium and phosphorus requirements of the body. The parathyroids, therefore, are responsible for normal teeth and bone development and the total structural growth of the body. Apparently the stimulus to parathyroid function is a low calcium level in the blood.

Should the parathyroids be damaged, removed, or stop functioning, hypoparathyroidism occurs. The most common symptom is tetany where the patient experiences numbness or tingling in the extremities, spasms in the feet, twitching of the facial muscles and a laryngeal stridor, which may be mistaken for bronchial asthma. Cataracts may form unless the blood calcium level is kept normal. If the hypoparathyroid patient does not receive continuous and adequate treatment, he may become mentally retarded. Diagnosis of hypoparathyroidism is generally through chemical analysis rather than through the symptoms, which are: marked muscular weakness, fatigue, poor appetite, constipation, difficulty in swallowing, dryness in the nose, loss of weight and apathy.

Hyperfunction of the parathyroids occurs three times more often in

females than in males and bone disease accompanies hyperparathyroidism. Although the general treatment is surgical removal, Reifstein stresses eliminating the cause of hormone overproduction rather than surgically removing the gland. (46)

F. *The Adrenals.* The adrenal glands sit like three-cornered hats on the upper part of each kidney. They produce the hormone adrenalin which is released into the blood stream particularly in times of stress to stimulate the body to vigorous action. Cortisone is another powerful adrenal hormone. Still other hormones are regulatory agents in mineral and salt retention and in fat, protein, and carbohydrate metabolism. Also produced by the adrenals is a group of hormones similar to and in relationship with the sex hormones.

The malfunction of the adrenal medulla, a part of the adrenal glands, is usually caused by tumors. The symptoms sometimes appear in children but are usually found in adults between twenty to fifty years of age, and these symptoms may continue for many years. The cardiovascular system is predominantly affected with patients suffering recurring attacks of hypertension or "spells".

When the adrenal cortex, another part of the adrenals, malfunctions, the condition has been present at birth or soon after. Hypofunction has an inhibiting influence on growth development. The child may be underdeveloped and thin, with poor chest development and breathing capacity. An adolescent suffering from hypofunction would be weak.

Hyperfunction of the adrenal cortex results in precocious sexual development of boys and in male body characteristics in girls. Both boys and girls tend to be very muscular. These hormones related to sexual development, therefore, play a part in the vigor and vitality of adolescents.

III. *Educational Implications*

Even though the relationship between learning and the endocrine system has not been thoroughly researched, there are indications that the ability to learn is greatly influenced by these ductless glands. The malfunction of any of the glands described would certainly affect the mind and body of the particular child so that he would not be at his optimum condition to do any kind of learning. In severe dysfunctioning situations, mental retardation results. Although the incidence may be only about 2% among all school children, these youngsters must be guided and taught in our schools. According to Karlin, research done by Donald E. P. Smith, led him to theorize that reading disabilities are related to the endocrine system. (26) Zintz concurs and stresses the need for help from the medical specialists without which teachers' efforts to teach reading will probably be unsuccessful. (1)

In her everyday association with pupils, a teacher learns how each one looks and behaves when he is well. Through several years of familiarity with a particular age group, the teacher tends to know how a child compares with his classmates. She is in the position, therefore, to notice significant changes for the worse in appearance and behavior without the subjectivity of parents. Often the teacher's observation that a doctor's advice is needed for a particular child is valuable.

Even in the normal process of maturation, the adolescent will be both proud and embarrassed by the hormone changes that are producing the secondary sex characteristics. During puberty adolescents may have skin disorders, and boys may be upset by their temporarily tender and enlarged breasts. Such children need to be reassured that their problems would soon clear up. With regard to the question of homosexuality, a popular misconception at the present time is that hormone insufficiency causes homosexual behavior, whereas there is no evidence that endocrine problems cause homosexuality. In fact endocrine therapy does not help homosexuals.

Another concern that may be guided by the classroom teacher is the use of hormones, specifically the thyroid hormones, and some of the steroids, for the treatment of certain diseases. Although it is presumed that students under medical care would have been informed by their doctors about the possible side effects of hormone treatment, sometimes the students do not know about the possible dangers. Teachers can, therefore, make their pupils aware of the need for full understanding about the complications.

The most common glandular malfunction to be found in the ordinary classroom is connected with diabetes. Doctors, parents, teachers and child must work together to help the child manage his own diabetic condition. Such management will lead to a normal life in and out of school. The teacher can be a continuous source of encouragement to helping the patient become self-reliant. The young diabetic child needs guidance in selecting and training for his future career, or else he tends to underachieve. This guidance by teacher and guidance personnel must be given very early.

The diabetic patient should be taught that he is different only for about 8 minutes a day while he tests his urine and takes his insulin. In general, all diabetic children can follow a normal school program of classroom activity, sports, and social affairs. His teacher must know about each diabetic child so that the teacher can act promptly if the child shows signs of insulin reaction or diabetic coma. Should the child not function normally at certain times of the day the teacher needs to notify the parents so that the food-insulin-exercise routine can

be adjusted. Most diabetic children learn about and heed their own systems, but in adolescence the disease is harder to control because of accelerated growth and the teenager's rebellious attitude toward his strict routine.

Another condition that may be common enough for teachers to be cognizant of is hyperthyroidism. Sometimes parents deny their child's disease. In a study of twelve hyperthyroid children, parents were uncooperative with the doctors and complained about their ill children. These children were often mothered by someone other than their own parent, and only one child in the study tried to be independent. (8)

It is important for each teacher to receive a list of the children who suffer from any endocrine disorder so that she can take his condition into account when the child appears listless or hyperactive, nervous, unable to see well, or when he becomes faultfinding for no apparent reason.

At the present time, there is no genuine connection between the function of the parathyroids and learning. According to Eames, there may be changes in the eyes when tetany occurs. (13)

Some influence on learning seems to be exerted by the adrenal, especially when the cortex is hypoactive, and the pupil lacks drive and is readily fatigued. There usually is emotional and psychological involvement when hyperfunction of the adrenal cortex results in sexual manifestations. Medical treatment fortunately is reducing the number of cases to be found in adolescents. However, it does not mean that these cases do not exist. Eames points out that secondary school and college students sometimes have an overactive pituitary gland which overproduces growth hormone. If caused by a growing tumor the disease may cause headaches and problems with the visual field. Eye span may decrease and cause more fixations in reading. (19) Thus both adrenals and the pituitary can influence school work.

Although clinical cretinism is at present relatively infrequent in this country, it is believed by some that mild hypothyroidism is already a social and educational problem. (4) Hypothyroid diseases can lower a child's capacity to learn even when he has been medicated from birth. Children with myxedema are likely to be slower at learning and their physical appearance makes them look slow. Since these children may be deaf and have slurred speech, their educational progress is likely to be less than what would otherwise be normal for them. Because in hyperthyroidism there are eye defects, fatigue, and nervousness, these children also tend to suffer in their school progress.

Pupils who have glandular difficulties do not have to be placed into special classes designed for them, since they can probably adjust to normal course work. In situations where the adjustment is not satis-

factory, the teachers involved and the administration should consider some program modification for students who obviously cannot handle the regular offerings.

IV. *Recommendations*

1. Diagnose hypothyroidism early in infancy to prevent severe physical and mental retardation. Diagnosis might be encouraged by publicity on birth defects and by establishing town well-baby clinics.

2. No doubt other endocrine problems have a psychological factor which requires observation and research for clarification. (14)

3. Anomalous development in children must be diagnosed early because the future will surely bring advances in chemotherapy. Except with regard to hypothyroidism, the relationship between behavioral development and endocrine dysfunction is not at present well defined. (19)

4. Keep a careful record of the occurrence of endocrine disorders (and other diseases) in the school system so continuous help can be given to the children as long as they remain in the school system.

5. Encourage medical doctors to observe the implications of a disease for the school system. Dr. Richard Field of Massachusetts General Hospital says that no recording of behavior was made of diabetics who could have been observed for social and psychological complications. (16)

6. Readjust the curriculum for children both with endocrine problems and with other physical problems. Physical therapy often helps these children improve their reading and other subjects. (48) Perhaps it would be possible to add physical therapy to the school day for some children.

7. Make efforts to improve the diets of school children as a means both of keeping proper endocrine function, (27) and of improving a child's nutritional status in general.

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Chemotherapy and the Hyperkinetic Child

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Introduction: The Problem and Definition of Terms

Recognition of the value of drugs and the application of chemistry in medicine is not recent in origin. Paracelsus, (1493-1541), a Swiss physician and biologist, pioneered in introducing the use of many drugs, some of his theories foreshadowing modern medical practices. (8) It would appear that the term "iatrochemistry" derived from the Greek roots *iatros*, meaning physician, and *chemia*, meaning chemistry—its meaning, then, "the science of chemistry applied to medicine," was current in medical literature preceding its modern counterpart, "chemotherapy."

The father of modern chemotherapy, Paul Ehrlich, sought a term that would express something other than what "iatro-chemistry" implied. As seen by Ehrlich, chemistry was not to be utilized in the treatment of disease, but rather in the destruction of the specific disease-producing living agents within the body of the diseased being. The aim of Ehrlich's chemotherapy was not therapy, in the traditional sense of the word, but inner sterilization. With the tremendous advances in the field of bacteriology in the 1930's, modern chemotherapy came into being. What differentiates ancient chemotherapy from its modern counterpart is the recognition of the existence of disease-producing organisms and the effort, by means of chemical agents, to destroy—or to effectively render harmless—such organisms within the body of the host. (16)

Russell pinpoints a basic assumption in many contemporary studies of behavior: the behavior patterns of a living organism are related, directly or indirectly, to events taking place in various biological subsystems within the organisms. (23) The general approach has been to observe the behavior of organisms in which the normal course of events in biological systems has been altered.

Although behavior appears to be related most closely to events in the nervous system and particularly the central nervous system, events

in other systems, e.g., the endocrine system, exert important influences. These biological systems have structural and dynamic features such that changes in one feature may be reflected by changes in the other. Basic to the dynamic features of a system are the biochemical events which characterize it in action and in its steady state. Drugs, as chemical agents which initiate or alter responses of biological systems, serve directly or indirectly by influencing the effects of other stimuli on a system. As stated by McIllwain, the relationship of chemotherapy to the central nervous system appears to be inherent in the reactions of the animal body to chemical substances. (17)

The hyperkinetic child is described as unable to sit quietly or to concentrate for a reasonable interval, failing through this lack of concentration, to master the skills of reading. Proper use of an effective drug can bring about increased concentration and consequent learning.

Doyle feels these "hyperkinetic" children comprise five percent of the school population. (6) Battista, using the results of a Columbia University survey, notes that conservatively ten percent of all public school children in the United States are emotionally disturbed in varying degrees. (2)

Through interviews and a survey of the literature, it was soon evident that this hyperkinetic child was the one to concern the teacher in a normal classroom situation. Since this is the problem upon which the writers wish to concentrate, an attempt has been made to sift through the literature, focusing as previously stated, upon the child in the normal classroom situation. An overlapping of the literature will inevitably result. A bias may be detected as concerns the child with reading problems, that being, in effect, a basic concern of all the writers involved.

Review of the Research

By way of definition, Solomons (27) has provided a guide for identifying the hyperkinetic child. This child may cause many difficulties for the family, school authorities, and the physician. It is important to keep in mind that:

1. There are many types of hyperactivity and therefore there exist many possible etiological factors and criteria for diagnosis.
2. This is a child who carries out activities at a higher rate of speed than the average child, or is constantly in motion, or both.

The principal features exhibited are chronic, severe hyperactivity and the absence of neurological defects which are usually considered to be due to brain damage. Because of the lack of gross neurological defects, the terms "minimal brain damage" and "minimal cerebral dysfunction" are used.

In his observation, Solomons categorizes children exhibiting such tendencies into the following groups:

1. Those possessing constitutional activity levels or inherent temperamental dimensions.
2. Those with immaturity or "maturational lag."
3. Children with emotional disturbance.
4. Those with diffuse brain damage.

In working with these children he found that amphetamine inhibits or lowers the level of synaptic transmission, or raises the level of synaptic resistance at the diencephalic level. It tends to restore the normal function of the diencephalon and thus prevents a flooding of the cortex by a stream of impulses.

Denhoff (5) concurs that the evidence is good that the dysfunctioning diencephalon in children with cerebral palsy and related syndromes can be favorably affected by drugs and maturation. This evidence suggests that these children, in addition to neuro-motor or sensory disability, the result of brain damage localized or generalized, may also suffer in part from a functional disturbance which can be favorably affected by proper understanding and treatment. Thus a view to which many workers in the field are coming is that the child with cerebral palsy and related disorders can be successfully treated when consideration is given to the sensory and emotional factors, as well as the neuro-motor responses. Since the terms "brain damaged child" or "brain injured child" connote permanent disability, it is suggested that these terms be replaced by the term "Syndromes of Cerebral Dysfunction."

This paper will deal with an analysis of the usage of the drugs, experimental programs utilizing such medication, and implications for the hyperkinetic child.

It has been suggested by Hawkey (10) that the human body is itself a chemical factory manufacturing drugs such as hormones and enzymes which regulate body processes, affect growth and aid digestion. Other drugs introduced into this system may react with the body's own chemicals, may inhibit, or stimulate body functions and may kill a disease producing organism in the body. The system is so complex that any tampering must be done with the greatest care and watchfulness.

Of all the drugs on the market today, 90 percent were virtually unknown twenty-five years ago as noted in *Changing Times*. (31) In further investigation of the situation, it is felt that while 90 percent of the users will benefit, another ten percent will have undesirable, sometimes fatal reaction to the drugs used. All drugs, by their very nature, have side effects. They are designed to interfere with the natural course of some bodily condition, i.e. pain, infection, etc. When this

happens, other changes in the physical functioning are bound to occur and some can be as undesirable as the ailment.

There is no such thing as an innocent drug. Reaction to a drug is adverse when its administration does more harm than good. A drug that is relatively harmless in itself can combine with others to produce lethal effects. Also, there is the element of allergy to be considered. A normal dose for one person may be a massive dose for another. The Federal Drug Administration has set up an "early warning system" to alert physicians by means of a computer as to possible risks with new drugs.

Marley (15) points out that scientists feel that they know little about the fate of drugs in the body. Pharmacologists say too many physicians use drugs without understanding how or why the drugs behave as they do.

Hawkery (10) concludes that among the stimulants, amphetamines are the most widely abused of all the stimulants. These drugs directly stimulate the central nervous system and the automatic nervous system. This medication is available only by prescription and could cause the individual to be nervous, restless, highly talkative, to have a rapid pulse, sweating, heightening blood pressure, muscular tremors, spasms, and sometimes mental disturbances. The tolerance to the drug grows so that increasingly large doses are needed to get the desired effect. A dependence may eventually be caused.

In reporting the various aspects of drug addiction, Radin (21) points out that dexedrine is an exhilarating stimulant. Barbiturates may lead to poor motor control and speech that may be inarticulate. There may be a sudden change from a warm and friendly person to an outburst of violence. Judgment becomes poor, and resorting to inner fantasies is common.

In studying activity levels due to the effect of amphetamine, McConnell (16) found that early studies have suggested that hyperkinetic behavior in children may result from a disturbance of the function of the diencephalon, and may be controlled by amphetamine drug administration. These studies have also indicated that while the hyperkinetic child tends to become quieter and more subdued while under amphetamines, he, at the same time, shows more initiative and general activity.

Claims have also been made that amphetamines tend to increase attention span, reduce impulsive and explosive behavior, improve intelligence test performance, and in general, cause the child to behave in a more socially acceptable manner.

McConnell (16) goes on to point out that most studies in this area are not experimentally controlled and have relied for the most part on clinical observations and have not applied statistical analysis to the

results. In his study, he attempted to determine the effects of dexedrine on the activity level of retarded children using a control triple-blind procedure with appropriate statistical techniques. Fifty-seven children were used and were administered dexedrine in three randomized dosage levels for three weeks. Ballistograph and rating scale measures of activity level were taken each week. There was no significant difference found among the three treatments on either measure. In conflict with previous research which has strongly suggested that dexedrine tends to slow down the hyperkinetic child and speed up the hypokinetic, it seems likely that most of the prior studies were influenced by uncontrolled variables, or that response to the drug is much less general than has been supposed.

Doyle (6) found that although we know a great deal about the usual retarded child, little is known about the child with emotional disorders. This child is often referred to as one having minimal brain damage, social dysparaxia, brain injury, CNS maturation delay, neurological handicaps, organic brain syndromes or cerebral dysfunction. He goes on to report that in his study, Bradley found that the child appears erratic, emotionally overactive, hyperkinetic, has poor power of concentration, and is given to sudden rages and is conspicuously impulsive.

Bawkins found that the moods of these children vary, frustration level is low, and they are impulsive and antisocial. The I.Q. is normal or slightly below normal. They perform poorly in auditory and visual memory and spatial orientation. They succeed better in verbal rather than performance tests.

Doyle (6) goes on to indicate some of the considerations which must be taken if drugs are to be used in working with these children.

1. If medicines are used properly and adequately, most people with wide experience feel they are of some value, although limited.
2. Turn away from blandishments of drug houses and select a half dozen different drugs, become familiar with their dosage and relative toxicity.
3. In no instance should drugs be used as a substitute for psychological, psychiatric or social help.
4. The efficacy of drugs is overestimated by drug houses.

Some university professors have disdained their use completely. The busy school physician, pediatrician, or family physician trying to be practical—knowing the absence of longitudinal studies administers these drugs realizing they take the edge off a tense, distracted child. The families of these children need counseling and at times psychiatric help in understanding the nature of the problem, ways of handling the affected child's hostility and impulsiveness. Problems in reading must

be dealt with patiently and sympathetically. Special treatment and classes are needed and long range studies must be made.

According to Schrager (26) mention of the syndrome of the hyperkinetic child is guaranteed to raise eyebrows in medical, psychological and educational circles. Disagreement exists concerning diagnostic appraisal and treatment of this child. Whether the hyperkinetic child is a product of insult to brain, disturbed interfamilial relations, poor genetic composition or a consequence of overwhelming social pressures is equivocal. Children can be identified by such symptoms as restlessness, inattention, being hard to manage, being unable to sit still, being easily distracted, and having a low frustration level. He studied seven children with reading difficulties. All of them exhibited abnormal EEG tracings, deviations in parietal, post temporal regions. There appeared to be some pattern between the extent of deviation and the degree of reading trouble.

Research in medical journals and publications from 1963 through 1968 concentrated on articles which deal with the effects of drugs on behavior of children with emotional and/or learning disabilities.

The majority of the articles were highly technical in nature, designed to test the effectiveness of a specific drug on a select group of individuals. An example of this type of research was reported by Fareta and Gozun. (7) This study was designed to measure the effectiveness of a drug known as prozine, a compound of meprobamate and promazine. Forty-nine male subjects between the ages of eight and fifteen were involved, twenty-one childhood schizophrenics, twelve behavior disorders associated with organic brain damage, and sixteen with primary behavior disorders.

The results of the study showed that this drug was most effective with those patients having behavioral disorders and with those having behavioral symptoms secondary to organic brain damage.

According to Hammond, (9) the concern of the physician for the hyperactive child and his family is paramount to successful treatment. He states that the hyperactive distractible impulsive behavior disorder is common, occurring in many as the result of mild central nervous system damage. The physician has the responsibility for diagnosis, for prescribing a course of treatment including chemotherapy and for consulting with parents, helping them evolve more realistic rearing techniques. He recommends the phenothiazine family of drugs as being helpful in relieving motility and attentive disorders and in facilitating better self-control. In conclusion, he states that any prescribed program of care can only succeed if the parents and child can be seen regularly and often.

In identifying the various components of the hyperkinetic syndrome, Laufer (13) found that the child of school age tries the patience of

the parents severely. Such a child does not fit into any scheme of family activity. The peculiar, impulsive, and almost explosive responses are particularly intolerable to many parents who find it difficult to accept from their children behavior which has an aggressive component. Such children may be beyond the ability of the teacher to tolerate. The specific learning difficulties usually in arithmetic, but frequently in reading as well, combine with the child's increasing unhappiness to make for school failure. The child frequently fails to gain a proper foundation for the fundamentals of schooling so that each successive year, he falls further behind.

Laufer (14) goes on to report that clinically, it has been seen that when the hyperkinetic syndrome exists alone, and has been recognized early, there may be only minimal associated emotional disturbance. However, even in these cases—although the favorable effect of the use of amphetamine on the behavior often induces an era of good behavior which has its own beneficial effect—a definite part of the treatment consists of work with the parents who frequently have feelings of guilt and also hostility. It is necessary to emphasize that the hyperkinetic syndrome is a very specific entity. It does not account for the majority of children's behavior disturbances, and differential diagnosis continues to be just as much needed as heretofore. He summarizes by noting that the situation is in time overcome by the operation of normal maturational processes. Until such takes place, apparently amphetamine and possibly other medications have a very specific ameliorating effect upon this syndrome by means of a direct action upon the diencephalon. This situation has many psychological and psychodynamic implications.

Drugs Most Commonly Used for Treatment

Most of the drugs previously mentioned are classified as 1) tranquilizers or 2) psychomotor stimulants, antidepressants and energizers. (22)

The tranquilizers are defined as "substances that reduce anxiety and agitation without clouding consciousness. (22) According to Berger, "Tranquilizers, as a rule, do not bring 'peace of mind' to normal persons; they may not affect them at all or may make them feel worse, while for the mentally ill person, they often do much more than eliminate agitation; they may facilitate social adjustment, eliminate delusions and hallucinations, or make mute patients communicative." (22)

The largest group of tranquilizers is the phenothiazine group. In 1960, twenty-one different phenothiazine compounds were listed, thirteen of which are used as tranquilizers. The balance include antihistamines, antispasmodics, antipruritics and antiparkinsonian agents. (22)

Chlorpromazine, commonly known by the trade name of Thorazine, is used for control of agitation, anxiety, tension, confusion and related

symptoms as seen in neuroses and other psychiatric conditions. The side effects noted include drowsiness, occasional dry mouth, nasal congestion, constipation, and sometimes an increase in appetite and weight occur.

Thiartidazine, commonly known by the trade name of Mellaril, has many diverse uses including treatment for anxiety-tension states, acute and chronic psychoneuroses, behavior problems in children and agitated geriatric patients. It has a "specificity of action on certain brain sites, in contrast to the more 'diffuse' action of other phenothiazines. (18) It has a wide margin of safety with major side effects rarely occurring.

Prozine is a combined psychotropic agent of meprobamate and promazine. (22) It is used for a variety of indications including behavioral problems in children. It can be habit-forming and thus must be regulated under close supervision.

The antidepressants to be considered are classified as direct stimulants used for the milder types of depression. They are used with retarded, socially regressed, apathetic, depressed patients whose symptoms are intensified by the tranquilizers.

Amphetamine sulfate, commonly known by the trade name of Benzedrine, is used for many indications. (18) Precautions against the excessive use of amphetamines by unstable individuals is given as it may result in a psychological dependence upon the drug. Side effects noted include insomnia, increased motor activity and hypertension.

Dextro-amphetamine sulfate, commonly known by the trade name of Dexedrine, "restores optimism and mental alertness, induces a feeling of energy and well-being, and revives normal interest, activity and capacity for work." (18) Dexedrine ordinarily produces the desired improvement of mood without giving rise to undesirable side effects.

As an amphetamine derivative, the precaution against psychological dependence is noted. Other side effects include loss of appetite, interference with sleep, and change of facial appearance. Solomons reports this facial change as the "panda syndrome," extremely pale and sallow with dark circles under the eyes. (27)

Methylphenidate hydrochloride, commonly known by the trade name of Ritalin, is a mild stimulant and antidepressant. (18) It has varied uses including functional behavioral problems in children such as hyperactivity and stuttering. It is also used to induce verbalization during psychotherapy. Marked anxiety, tension and agitation are contraindications since the drug may aggravate these symptoms. Side effects reported include loss of appetite and/or nervousness or emotional lability. These side effects were not substantiated objectively in a study by Conley. (27)

Interviews

In an attempt to further clarify our thinking concerning the subject of drugs and their use with children who are in a normal classroom situa-

tion, it was decided to conduct a series of interviews with individuals who have particular interest or concern with this problem.

Dr. Maurice Laufer, Director and Psychiatrist in Chief of the Emma Pendleton Bradley Hospital in Providence, Rhode Island, who has been using drugs, particularly amphetamines, in a clinical situation for a number of years was interviewed.

A pediatrician, Dr. H. Lester Medlinsky of Marblehead, gave his rationale for the prescribing of drugs to overactive and inattentive children.

Dr. Richard Curran, a practicing psychiatrist in the North Shore area and a psychiatric consultant at the Nazareth Home for Children, was consulted because of his reluctance to use drugs as a temporary solution to often deep-rooted problems.

A teacher in a local school system gave her impressions of some of the children in her classroom and their behavior before and after they were treated with drugs.

A mother of a child who is considered to be hyperkinetic, described her son's reaction to drug treatment.

A visit was also made to the Emma P. Bradley School in Providence, Rhode Island, to observe, first hand, emotionally disturbed children who have been removed from their home situations, and who are treated on a full-time basis at the school and at the hospital. Pertinent to this paper are the following observations:

In an interview at the Emma Pendleton Bradley Hospital, Dr. Maurice W. Laufer defined the hyperkinetic impulse disorder in a child as that disorder caused by an abnormal disfunction of the central nervous system. Although it is not to be confused with brain damage, it involves specific learning difficulties and communicative problems. The child displaying this disorder can be recognized by all or only some of the following syndromes: he may be overactive, easily distracted, concerned with everything about him, impulsive, impatient, and unpredictable. He is notoriously accident prone and may be explosively irritable. These behavioral disturbances and the fact that there is often some specific learning disability in the area of reading and arithmetic, make it difficult for a child to participate successfully in school work. Dr. Laufer explained that there seems to be compound problems in the visual-motor-perception and concentration areas, and that reversals in reading and writing as well as cramped and irregular handwriting are frequent.

Dexedrine and Benzedrine, used with 30% of the children treated at the hospital serve to slow the children down. The side effects produced by these drugs, the amphetamine look—pale and pinched with dark hollows under the eyes, sometimes loss of appetite or difficulty

in getting to sleep, are considered unimportant except that they may disturb parents. Since the hyperkinetic condition is usually outgrown between the ages of twelve and eighteen there is no chance of addiction. Dr. Laufer stressed that drug administration alone was insufficient and pointed to the need for special help for associative learning difficulties.

A leading pediatrician, Dr. H-Lester Medlinsky, advocates the use of drugs with the hyperkinetic child to neutralize over-activity that may lessen the span of attention. With the hyperkinetic syndrome brought under control, the child is better able to concentrate on the learning at hand with less interference. He points out that the drug dosage may have to be increased but that the patient suffers minimal ill effects, and with maturation the hyperkinetic syndrome may be outgrown and the need for chemotherapy ceases to exist. Dr. Medlinsky stresses the need for communication between the pediatrician, parent and the teacher to evaluate the effects of the administered drug upon behavior and personality in and out of the classroom situation.

Dr. Richard Curran does not approve of the use of drugs with over-active children. He feels that at best this is just a stop gap measure, and prefers the alternative to prescribing drugs—counseling for the child and his family. He feels that often drugs are prescribed to placate the teachers and/or parents. They are unable to cope with the children, and, therefore, find the calmer child on drugs much more to their liking.

Another factor is the expense involved with psychological treatment compounded by the limited number of psychiatrists who specialize in children's work. It is easier to consult the family pediatrician and have a relatively inexpensive drug prescribed.

Many children are in a hyperkinetic state as a reaction to family life. Many parents have not matured to the point where they can freely give love in an unselfish manner to their children. They are still much too concerned with receiving it. Until this transition is made, problems will persist.

A second grade teacher on the faculty of a suburban school in the greater Boston area reports positively that several children in her classroom are easier to handle since being treated with drugs by a pediatrician. She notes that prior to treatment they were over-active in class, unable to concentrate, never finished their work and, consequently, had difficulty with school work, particularly with reading and arithmetic. Since they have received medical attention, most of these conditions have modified. In general, they are in much better control of themselves, and are, therefore, easier to handle in a school situation.

The mother of a young hyperkinetic child states that since her son,

on the recommendation of a pediatrician, has been treated with Atarax, a mild tranquilizer, there has been a definite improvement in his behavior and consequently a lessening of tensions within the family situation. Prior to this the boy had exhibited all the manifestations of a hyperkinetic child.

The child was into and onto everything, forcing his parents to put locks on the more dangerous places in the home. As one solution, it was decided to send him to nursery school to see if contact with other children would help him. For a time it seemed to help, but soon his teachers began to complain about his behavior. They were particularly upset when he threw the record collection into the fish tank.

Although the mother notices that he does at times tend to be listless and apathetic, and that the dosage has to be increased periodically to maintain the desired effect, the mother feels that the good effects of the drugs outweigh its disadvantages.

Visitation to a Treatment Center

The Emma Pendleton Bradley Hospital in East Providence, Rhode Island, is a residential treatment center for children who are severely emotionally disturbed. These children have the potential for average or better than average intelligence. As part of the program for rehabilitation, the children attend the Bradley School, part of the hospital complex.

There are 65 children currently enrolled in the school from Rhode Island, Massachusetts, Connecticut, Maryland, and New Jersey. They range in age from six to eleven. Classes are small, consisting of four to seven children, allowing for close individual attention by the teachers. The teachers all have previous elementary experiences and possess Masters degrees in Special Education or are working on said.

The classes were in session and all proceeded much like the average public school as the visitors journeyed from class to class. Unlike the public school, however, there was evidence here of close ties between the medical staff, the individual therapists (psychologists) assigned to each child, the unit leaders (surrogate parents) and the teachers. These factors, plus the advantages of small classes, have served to reestablish in society many of these children as useful and productive citizens.

Summary

It was the purpose of this paper to gather information concerning the utilization of drugs specifically with the hyperkinetic child. The investigation dealt with:

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1. A review of the current practices utilizing the various amphetamines.
 2. The most common drugs used in treating hyperkinetic children.
 3. A series of interviews with persons dealing directly with children receiving such treatment.

The concern of the investigation was the problem facing a classroom teacher when confronted with a hyperkinetic child in her room, and ways in which to promote better understand of the situation.

From the information received, the following assumptions were made:

1. The drug most commonly employed in the treatment of hyperkinetic children is the classification called amphetamine.
2. Experimentation to this date has been more clinical observation rather than statistical analysis.
3. The long range and side effects have not yet been fully determined. Observations indicate that withdrawal from drug treatment is complete without any tendency to addiction, and the ability to rejoin the normal society is made without any difficulty. In some cases children have gone on to successful careers, and in some instances have come back to work with children exhibiting hyperkinetic tendencies.
4. Opinions vary greatly as to the value of using drugs for treating hyperkinetic children.

Recommendations for Teachers

Identification of the needs of the child displaying hyperkinetic tendencies is of prime importance to the classroom teacher. The frustrations witnessed to this point have created definite learning gaps. Added to this the experience of constant failure is likely to have compounded the child's general hyperkinetic tendencies.

Developing a program for such a child necessitates an ingenuous and considerate teacher. Specific phases of the curriculum which are lacking must be identified and instruction provided in those areas. Time and patience are essential. A variety of techniques are to be employed that provide practice at the child's level and rate and that consider his specific sub-skill needs. High intensity techniques and those that make use of higher mental processes should also be considered. Success will not be immediately apparent for one makes progress slowly and intermittently with this type of child.

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